CLAIMS

What is being claimed is:

1. A light emitting device comprising:

a III-nitride semiconductor structure including an active region disposed between an n-type and a p-type region; and

a photonic crystal structure formed in an n-type region.

2. The device of claim 1 wherein the photonic crystal structure comprises a periodic variation in a thickness of the n-type region.

3. The device of claim 1 wherein the photonic crystal structure comprises a planar lattice of holes.

4. The device of claim 3 wherein the lattice has a lattice constant a between about 0.1 λ and about 10 λ, where λ is a wavelength of light emitted by the active region.

5. The device of claim 3 wherein the lattice has a lattice constant a and the holes have a diameter between about 0.1a and about 0.5a.

6. The device of claim 3 wherein the holes have a depth between about 0.05 λ and about 5 λ, where λ is a wavelength of light emitted by the active region.

7. The device of claim 3 wherein a lattice type, lattice constant, hole diameter, and hole depth are selected to create a predetermined radiation pattern.

8. A light emitting device comprising:

a first layer of first conductivity type;

a first layer of second conductivity type;

an active region disposed between a layer of first conductivity type and a layer of second conductivity type;

a tunnel junction, the tunnel junction comprising:

a second layer of first conductivity type having a dopant concentration greater than the first layer of first conductivity type; and

a second layer of second conductivity type having a dopant concentration greater than the first layer of second conductivity type; and

a third layer of first conductivity type;

wherein a thickness of the third layer of first conductivity type varies periodically;

wherein the tunnel junction is between the first layer of first conductivity type and the third layer of first conductivity type.

9. The device of claim 8 wherein:

the second layer of first conductivity type has a dopant concentration ranging from about $10^{18}cm^{-3}$ to about $5x10^{20}cm^{-3}$; and

the second layer of second conductivity type has a dopant concentration ranging from about $10^{18}cm^{-3}$ to about $5x10^{20}cm^{-3}$.

10. The device of claim 8 wherein the second layer of first conductivity type has a dopant concentration ranging from about $2x10^{20}cm^{-3}$ to about $4x10^{20}cm^{-3}$.

11. The device of claim 8 wherein the second layer of second conductivity type has a dopant concentration ranging from about $7x10^{19}cm^{-3}$ to about $9x10^{19}cm^{-3}$.

12. The device of claim 8 wherein the tunnel junction has a voltage drop ranging from between about 0V to about 1V when operated in reverse-biased mode.

13. The device of claim 8 wherein the tunnel junction has a voltage drop ranging from between about 0.1V to about 1V when operated in reverse-biased mode.

14. The device of claim 8 wherein:

the second layer of first conductivity type has a thickness ranging from about 1 nm to about 50 nm; and

the second layer of second conductivity type has a thickness ranging from about 1 nm to about 50 nm.

15. The device of claim 8 wherein the tunnel junction has a thickness ranging from about 2 nm to about 100 nm.

16. The device of claim 8 wherein the active region comprises III-nitride material.

17. The device of claim 8 wherein the periodic variation of thickness comprises a planar lattice of holes.

18. The device of claim 17 wherein the planar lattice is selected from the group consisting of a triangular lattice, a square lattice, a hexagonal lattice, and a honeycomb lattice.

19. The device of claim 17 wherein the planar lattice includes more than one lattice type.

20. The device of claim 17 wherein the lattice has a lattice constant a between about 0.1 λ and about 10 λ, where λ is a wavelength of light emitted by the active region.

21. The device of claim 17 wherein the lattice has a lattice constant a between about 0.1 λ and about 4 λ, where λ is a wavelength of light emitted by the active region.

22. The device of claim 17 wherein the lattice has a lattice constant a and the holes have a diameter between about 0.1a and about 0.5a.

23. The device of claim 17 wherein the holes have a depth between about 0.05 λ and about 5 λ, where λ is a wavelength of light emitted by the active region.

24. The device of claim 17 wherein the holes are filled with a dielectric.

25. The device of claim 24 wherein the dielectric has a dielectric constant between about 1 and about 16.

26. The device of claim 8 wherein the third layer of first conductivity type has a thickness of at least 0.1 microns.

27. The device of claim 8 further comprising:

a first electrode electrically connected to the first layer of first conductivity type; and

a second electrode electrically connected to the third layer of first conductivity type.

28. The device of claim 27 wherein the second electrode comprises a sheet attached to the third layer of first conductivity type, wherein the sheet contacts only thicker portions of the third layer of first conductivity type.

29. The device of claim 8 wherein the periodic variation of thickness is formed on a first portion of the third layer of first conductivity type, the device further comprising an electrode electrically connected to a second portion of the third layer of first conductivity type.

30. The device of claim 8 wherein a ratio of the period of the periodic structure and the wavelength of light emitted by the active region in air is about 0.1 to about 5.

31. The device of claim 8 wherein:

the periodic variation of thickness comprises a lattice of holes; and

a lattice type, lattice constant, hole diameter, and hole depth are selected to create a predetermined radiation pattern.

32. A method comprising:

forming a first layer of first conductivity type;

forming a first layer of second conductivity type;

forming an active region between a layer of first conductivity type and a layer of second conductivity type;

forming a tunnel junction, the tunnel junction comprising:

a second layer of first conductivity type having a dopant concentration greater than the first layer of first conductivity type; and

a second layer of second conductivity type having a dopant concentration greater than the first layer of second conductivity type;

forming a third layer of first conductivity type; and

forming a plurality of holes formed in the third layer of first conductivity type;

wherein:

the tunnel junction is between the first layer of first conductivity type and the third layer of first conductivity type;

the plurality of holes formed a lattice; and

a lattice type, lattice constant, hole diameter, and hole depth are selected to create a predetermined radiation pattern.